4.1 Our atmosphere

Lesson outcomes

At the end of this activity students will be able to:

- describe the significance of Earth's atmosphere through a comparison with conditions on Earth and on the Moon.

What ideas might your students already have?

Students at this level are sometimes still confused about whether the Moon has an atmosphere or not.

Key vocabulary:

Infra-red radiation, absolute zero

Equipment list

The CLASS will require:

- Internet access

Each STUDENT will require:

- ***Notebook***

Things to consider

This is intended to be a relatively concise activity, and may not take up much class time. It is possible that students could complete it at home before commencing this Part. Conditions on the Moon can be explored directly through videos of various Moon landings available through the NASA website.

Lesson plan:

Step 1: Students discuss in small groups the differences between the Earth and the moon and try to explain the differences in temperature experienced on each.

Step 2: Follow through with the digital activities to develop deeper understanding.

Step 3: Students revise their ***Notebook*** explanations in the light of the digital rollover and video.

Suggested questions:

What are the indicators on the Moon that it lacks an atmosphere?

What indications are there that the Moon that lacks an atmosphere?

4.2 Atmospheric layers

Lesson outcomes

At the end of this activity students will be able to:

- describe the atmosphere in terms of a model with invisible layers that are marked by differences in atmospheric pressure, temperature, height above Earth, and their gaseous components
- explain that wind patterns are a result of the heat of the sun and the turning of the Earth
- explain how clouds form
- describe ozone, the ozone hole and its cause, and some of the historical, scientific and political events that took place globally in recognising its adverse impact on Earth.

What ideas might your students already have?

Students are likely to be aware of the atmosphere and weather patterns. It is unlikely they can interpret weather maps or have considered the nature of the atmosphere as you move further away from Earth. There may be confusion between the ozone layer and the greenhouse effect.

Key vocabulary:

Exosphere, Thermosphere, Mesosphere, Stratosphere, Ozone layer, Troposphere, ozone hole, ultraviolet (UV) radiation, weather patterns, cloud seeding, cloud condensation nuclei (CCN), chlorofluorocarbons (CFCs), Montreal Protocol.

Equipment list

Each STUDENT will require:

- internet access
- ***Notebook***

Things to consider

The implosion of the oil container can be performed as a teacher demonstration and is a dramatic and memorable experience. Explore beforehand the concept of air pressure using the **Student Guide** diagram of the 1 cm2 air column. Students are surprised that the atmosphere exerts such pressure.

Use local and current weather maps (from the local paper or internet) for the class activity. Relating weather patterns and issues to local or national campaigns (e.g., UV index, fire warnings,) will engage students. As a class, lead students through the Bureau of Meteorology (BOM) website (www.bom.gov.au). Refer to *What do weather maps show?* (http://www.bom.gov.au/info/weathmap/showwhat.htm).

The cloud in a bottle experiment will work with any aerosol like deodorant, insect spray or air freshener. It will also work using smoke from a blown-out candle. Once the cloud forms students can lift off the lid and see the cloud rise and disperse into the air.

Emphasise the layers of the atmosphere are a simplistic model for us to better understand it – the layers are invisible.

A popular misunderstanding is that the Ozone layer is responsible for climate change. Ensure students can differentiate the ozone layer from global warming. Reinforce that they are different issues.

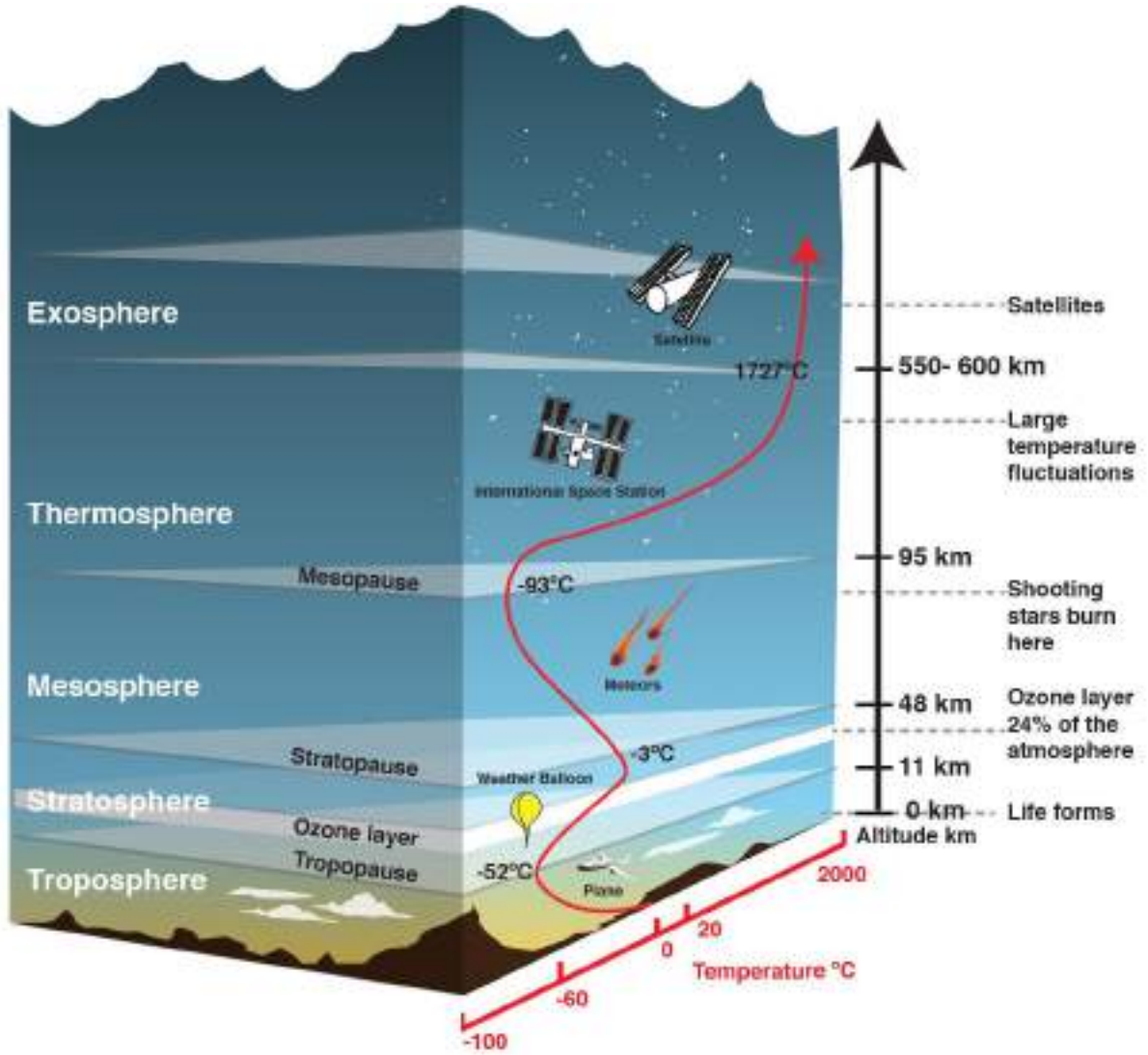
Addressing the Ozone hole is a powerful case study to illustrate the importance of scientific developments, understanding and taking responsibility of a global problem.

Students may be interested in building a school-based weather station to collect data for the term. http://school.discoveryeducation.com/lessonplans/activities/weatherstation/ or http://www.bom.gov.au/info/weatherkit/index.shtml

Teacher content information:

Weather occurs in the troposphere and varies at a given time and place. Climate is the average weather for a particular place over many years. Weather is strongly influenced by the uneven heating of the atmosphere by the sun (Earth's tilt and orbit etc.), wind circulation and moisture (water cycle) around the globe. The motion and interaction of large air masses causes many weather phenomena.

Ensure you are familiar with sourcing relevant content from the BOM website.



Some useful resources:

http://www.education.noaa.gov/Weather_and_Atmosphere/ (weather events)

http://www.cmar.csiro.au/index.html (research in Australia on climate and weather)
http://earthguide.ucsd.edu/earthguide/diagrams/atmosphere/ (interactive tool to learn about the atmosphere)

http://www.bom.gov.au/info/weathmap/showwhat.htm (reading weather maps).

Lesson plan

Step 1: Direct students to the diagram of a 1 cm by 1 cm column of air above the Earth and explain that air pressure at the base of that column is the weight of the entire column of air. Calculate as a class the surface area of the oil can and the total mass of air it is supporting. Begin the implosion demonstration, explaining how water changes to steam and pushes most of the air out of the oil can. If the bung makes a good seal the implosion will be dramatic!

Step 2: Point out to students the isobars on a weather map. Identify areas of low pressure and high pressure. Winds blow from areas of high pressure to areas of low pressure. The closer the isobars the stronger the winds.

Step 3: Form students into small groups and make clouds in jars. Note – students need use only the briefest squirt of the aerosol.

Step 4: Invite students to click on the digital link and explore the layers of the atmosphere. The videos consolidate nicely the previous learning in this activity.

Step 5: Brainstorm what students already know about the ozone layer. Invite students to read about the formation and destruction of ozone occurring in our atmosphere. Emphasise the importance of ozone in screening us from harmful UV rays. Ozone is also a greenhouse gas, however, it is not a man-made greenhouse gas.

Step 6: Invite students to explore the *Find out more*. The Montreal Protocol is a refreshingly good news story of how world governments can act together to avert a global catastrophe.

Suggested questions:

1. What is the atmosphere and how is it important in influencing weather and climate?
2. Why are changes in atmospheric gas composition a concern?
3. What are the similarities and differences between the ozone layer and the greenhouse effect?

4.3 Carbon cycle

Lesson outcomes

At the end of this activity students will be able to:

- describe the key components of the carbon cycle
- explain the implications of human activity (including industry and deforestation) on the carbon cycle.

What ideas might your students already have?

It is likely students have some awareness of the carbon cycle from other units e.g., **Rock Paper Scissors**, **Ecosystems and Change**. However, the ***Notebook*** questions will help them test their understanding at a deeper level, and in terms of climate change.

Key vocabulary:

Greenhouse gases, atmosphere, carbon cycle

Equipment list

Each STUDENT will require:

- internet access
- ***Notebook***

Things to consider

There are many layers to understanding the carbon cycle. Start with simple descriptions then, depending on student ability, you can elaborate at the chemical level (see *Teacher Content Information* below).

A class discussion will enhance their understanding of the cycle and its relationship with climate change. Encourage students to see what they can recall by drawing their own carbon cycle and including comments on how the balance of greenhouse gases is changing.

Teacher content information:

Some useful equations to consider for deeper analysis of the carbon cycle are:

<u>Photosynthesis:</u>

- Most simply: $6CO_2 + 6H_2O$ (sunlight, chlorophyll) → $C_6H_{12}O_6 + 6O_2$.

<u>Respiration:</u>

- Most simply, aerobic respiration: $C_6H_{12}O_6 + 6O_2$ → $6CO_2 + 6H_2O$ + energy (2830 kJ/mol).

<u>Human caused emissions</u>:

- Essentially: $C + O_2$ → CO_2 + energy (394 kJ/mol)
- More specifically: burning methane from natural gas

  $CH_4 + 2O_2$ → $CO_2 + 2H_2O$ + energy (890 kJ/mol)
- Burning octane in petrol - $2C_8H_{18} + 25O_2$ $16CO_2 + 9H_2O$ + energy (5470 kJ/mol)

Anaerobic respiration:

- Various possible, most simply: $C_6H_{12}O_6 \rightarrow 2CO_2 + 2C_2H_5OH$ (ethanol).
- Air/sea gas exchange: $CO_2 + H_2O \rightarrow (2H^+ + CO_3^{2-})$

Lesson plan

Step 1: Guide students through the digital activities and ***Notebook*** questions.

Step 2: Through a class discussion, examine the carbon cycle and its relationship to greenhouse gases and global warming.

Suggested questions:

1. What is happening to the carbon cycle on a big scale?
2. What other cycles exist in the environment and how do they cross-over with the carbon cycle?
3. How does the carbon cycle influence greenhouse gases in the atmosphere, and subsequently climate change?

4.4 Is the climate changing?

Lesson outcomes

At the end of this activity students will be able to:

- explain the meanings and differences between weather, climate and climate change
- describe some of the extreme weather events associated with global warming
- describe some of the climate drivers that influence Australia's climate.

What ideas might your students already have?

Students are likely to have some awareness of global warming, especially via media attention on extreme weather events and community debate on local or global action (e.g., carbon tax, living green, sustainability etc.). Some misconceptions are likely in understanding the differences between weather, climate change and global warming, and understanding the nature of greenhouse gases and their effect on the atmosphere and subsequent warming of the Earth's surface.

Key vocabulary:

Climate, weather, debate, global warming.

Equipment list

The CLASS will require:

- access to internet.

Each STUDENT will require:

- ***Notebook***

Things to consider

This activity focusses on the distinction between the concepts of weather and climate. Students may find the concept of climate, as an average of weather conditions over larger scales of time and space difficult.

Teacher content information:

There are many misconceptions and misunderstandings regarding climate change science, global warming, the greenhouse effect, extreme weather events and the distinction between weather and climate. The following information provides background to this activity, but is also applicable to several activities within **Part 4**.

In brief:

- Global warming refers to the increase in the Earth's average surface temperature (over a long period of time). Global warming is thought to be primarily due to changes in the atmosphere's greenhouse gases. While Earth's average temperature has risen over time, the increases now observed are unprecedented and thought to be largely due to population and human activity (refer to carbon cycle).
- Scientific evidence to support concerns includes observed long-term changes in the Antarctica and Arctic ice caps, sea-level rises and ocean acidity levels, frequency of extreme or record-breaking weather events, sea and land average temperature recordings, carbon emissions and atmospheric changes (greenhouse gases), as well as observed changes in the biodiversity and adaptation of living organisms. See '*Projections for regional climate change in Australia'* - https://www.climatechangeinaustralia.gov.au/en/climate-projections/future-climate/regional-climate-change-explorer/super-clusters/

- Weather and climate are different. Climate describes average temperature ranges for a particular region over a long period of time. Weather and climate changes reflect changes to the planet on a big scale – they are not just due to local factors (e.g. what happens to the vast forests across Asia will impact on global warming and hence weather patterns in other regions of the world).
- There has been a significant global, local, political, scientific and community response to the global warming debate (e.g. Kyoto Protocol), however due to predicted human industrial activity and population growth, global warming will increasingly become a chief concern for our planet's future.
- Australia's climate is influenced by different climate drivers that together influence our seasonal rainfall. These drivers are:-
    - Sub-tropical Ridge
    - Madden-Julian Oscillation
    - El Nino Southern Oscillation
    - Southern Annular Mode
    - Indian Ocean Dipole
    - East Coast Low

An overview of the science of climate change can be found on the Australian Academy of Science website - https://www.science.org.au/climatechange

Other useful teacher resources:

- The Earth Systems and Climate Change (ESCC) Hub, established in 2015, is hosted by CSIRO and is a partnership of Australia's leading Earth systems and climate change research institutions: http://nespclimate.com.au/
- Australian Government: www.climatechange.gov.au https://www.climatechangeinaustralia.gov.au/en/
- CSIRO: https://www.csiro.au/en/Research/OandA/Areas/Oceans-and-climate/Climate-change-information
- ABC: http://www.abc.net.au/science/tag/browse.htm?topic=enviro&tag=climate-change
- Bureau of Meteorology: http://www.bom.gov.au/climate/change/#tabs=Tracker&tracker=timeseries http://www.bom.gov.au/state-of-the-climate/
- NASA: https://www.nasa.gov/subject/3127/climate/
- TED talks about climate change: https://www.ted.com/topics/climate+change

Lesson plan

Step 1: Have students brainstorm their understanding of the terms weather, climate and climate change. Direct students to the definitions in the *Student Guide* and complete the two questions posed.

Step 2: Explore the *Student Guide* and digital activities. Draw students attention to the graphic showing the movement of low pressure systems across Australia. Ask students to relay any experiences they have had in regard to extreme weather, or experiences their parents may have had.

Step 3: The important message for students after watching the '*Climatedog*' animations is that our weather and climate are influenced by several climate drivers and hence it is very difficult to predict future weather. As a class discuss students' answers to the ***Notebook*** questions.

Suggested questions:

(These questions can be asked throughout **Part 4** as students increase their understanding of climate change).

- What is global warming and how is it related to weather and climate?
- What is the key scientific evidence supporting global warming?
- Why is global warming a concern?

4.5 Greenhouse effect

Lesson outcomes

At the end of this activity students will be able to:

- use a greenhouse environment to explain about incoming sunlight, re-emitted infrared radiation and temperature increases
- gather and interpret data obtained in their greenhouse experiment
- describe the similarities and differences between planet Earth and a greenhouse.

Key vocabulary:

Greenhouse, greenhouse effect, infrared, hypothesis, variables, temperature, carbon dioxide.

Equipment list

Each STUDENT will require:

- *Student Guide*
- ***Notebook***
- internet access
- equipment outlined in the *Student Guide* for each investigation.

Things to consider

- The cardboard boxes that deliver A4 photocopying paper to your school make ideal greenhouses. Cheap A4 photo frames from dollar shops provide the panes of glass.
- Portable digital infrared non-contact thermometers are available online for about $10 - $60.
- Encourage students to explore other on-line student investigations of the greenhouse effect and approaches used before they conduct their own.
- Write up the experiment as a formal research report. This can be used for evaluative purposes.

Teacher content information:

There are plenty of information and handouts on the internet for conducting greenhouse investigations. Depending on student ability, time and equipment available at your school, you may need to provide more structure and guidance for the second experiment. Either the first or second experiments, or both, can be used as an assessment item.

Infrared radiation is the electromagnetic radiation that spans wavelengths from being just longer than visible red light (700 nm) to just less than microwaves (1,000,000 nm or 1 mm).

Short wavelength infrared or near infrared acts pretty much the same way as visible light. It can pass through glass. It is not visible to humans but it is visible to the CMOS and CCD sensors in digital cameras. TV remote controls emit near infrared and this is explored in **Activity 5.3** of **Light, Sound, Action** where students use their mobile phone cameras to detect this light.

Thermal infrared is in the middle band of IR wavelengths and is not detected by normal camera sensors even with the IR-cut filter removed. Thermal infrared is produced by matter around room temperature and is the IR radiation that is absorbed by the greenhouse gas CO2. Thermal infrared radiation is strongly absorbed by matter and will not pass through glass. Infrared non-contact thermometers measure at this wavelength and will not register the temperature of a hot object on the other side of a pane of glass.

Lesson plan

Step 1: Organise students into groups and follow the instructions to construct greenhouses. Take care with the glass panes.

Suggested questions:

- Is your experiment a fair test?
- How does your experiment account for temperature changes?
- What were the limitations of your investigation?
- How would you improve your investigation of the greenhouse effect?

Step 2: If you do not have enough infrared non-contact thermometers for all groups the second activity could be a teacher demonstration.

Step 3: Direct students to the digital activity illustrating the greenhouse effect and the ***Notebook*** task that consolidates the learning in this activity. Discuss and share students' responses to the ***Notebook*** task.

4.6 Human influences

Lesson outcomes

At the end of this activity students will be able to:

- describe global warming, its causes and influencing variables, including human activity
- name the greenhouse gases and how they impact on Earth's surface temperature
- describe the relationship between global warming and the enhanced greenhouse effect.

What ideas might your students already have?

From earlier activities, students are likely to have some awareness of how the atmosphere and greenhouse gases have led to global warming. This is an opportunity to clarify and consolidate their learning in terms of the relationship between greenhouse gases and surface temperature.

Key vocabulary:

Atmosphere, greenhouse gases, methane, radiation.

Equipment list

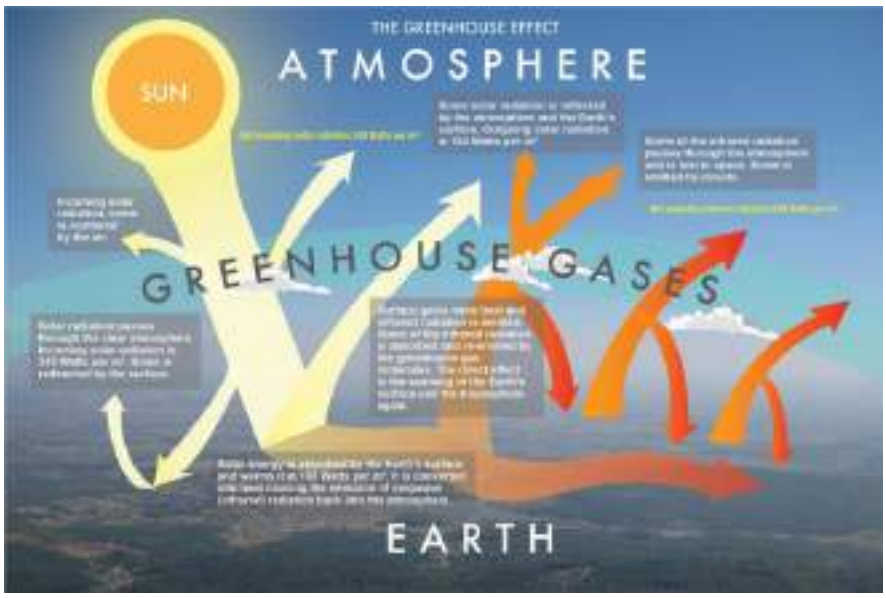
Each STUDENT will require:

- ***Notebook***
- internet access

Things to consider

- Use the *Student Guide* and supporting videos to elaborate on global warming, and the impact of human activity on increased greenhouse gases in the atmosphere, and possible local actions. You may wish to project all videos onto a screen for whole class viewing.
- Encourage students to summarise key issues in dot points after watching each video.
- Clarify explanations relating to the enhanced greenhouse effect and surface temperature.

Teacher content information:



Increased concentrations of these gases send trapped radiation back to Earth, warming its surface.

Lesson plan

Step 1: Begin with the *Student Guide* and the history of carbon dioxide emissions. Allow students to explore the rollover images about greenhouse gases and delineate between the greenhouse effect and the enhanced greenhouse effect.

Step 2: Present each of the videos to the class and ask students to jot down dot point summaries of each video.

Step 3: Invite students to begin the ***Notebook*** tasks. Students might like to form small groups and view the short videos together. Encourage students to explore the various plans to mitigate climate change.

Suggested question/s:

- What are the greenhouse gases?
- What human activities lead to the enhanced greenhouse effect?
- What can we do to reduce global warming?

Follow up:

In the *Find out more* section students can learn about how to apply action locally to reduce the carbon footprint.

4.7 Oceans, ice and climate change

Lesson outcomes

At the end of this activity students will be able to:

- describe how multi-disciplinary research in polar regions is providing scientific evidence for changing climate conditions on a big scale
- describe the impacts of melting ice sheets and sea ice from the polar caps.

What ideas might your students already have?

It is likely students will have some awareness of sea-level variation due to climate change, melting ice caps, receding snow lines, ice cores and Australia's involvement in Antarctica research.

Key vocabulary:

Hydrosphere, cryosphere, glacier, permafrost, polar, Antarctica, Arctic, ocean currents, Indian Ocean Dipole (IOD), global conveyor belt, thermohaline circulation.

Equipment list

Each GROUP will require:

- 2 large, identical troughs
- 2 house bricks
- 2 large blocks of ice, each representing about 20% of the water volume in the trough
- Heat source (direct sun or lamp)
- 6 thermometers
- 2 rulers
- Adhesive tape

Each STUDENT will require:

- ***Notebook***
- internet access

Things to consider

- You might prefer your students to learn about the Polar Regions through the digital resources before attempting their hands-on experiment.
- Encourage students to manipulate investigation conditions or the method in order to improve it – without jeopardising fair test principles.
- Encourage students to interact with Antarctica scientists through their blogs to learn more about careers and working remotely.
- The video ***Why is Greenland melting?*** is a 360° video. It plays well on desktop computers and laptops where you can click and drag to choose different viewpoints of the environment as the video is running. This video does not work on iPads, tablets and smart phones.

Teacher content information:

- The cryosphere is that part of the Earth's surface which includes snow, land and sea ice, such as permafrost, ice bergs and glaciers.
- Sea ice floats in the sea and therefore melting sea ice does not affect sea level. The loss of sea ice does affect Earth's albedo. Sea ice reflects sunlight back into space and the loss of sea ice results in an increase in the absorption of sunlight by the ocean.
- Ice sheets are expanses of ice located on land (e.g. Greenland, Antarctica). The melting of ice sheets results in an increase in sea level.
- Indian Ocean Dipole (IOD) refers to the irregular and variable cycle of warming and cooling of waters in the equatorial Indian Ocean.
- Global conveyor belt: the common term for the thermohaline circulation tracked around the whole Earth.
- Thermohaline circulation: the continuous circulation of water around Earth driven by global density gradients created by surface heat and freshwater fluxes.

Lesson plan

Step 1: Progress students through the *Student Guide*, developing the distinctions between sea ice and ice sheets.

Step 2: Have students set up their simulation experiments of melting sea ice compared with melting ice sheets. Ensure both troughs have the same water level at the beginning.

Step 3: You might like to have students' record temperature and water level changes interspersed with watching the short videos on the Polar Regions. Allow time to discuss the discussion questions. See if your students can improve the ice investigation model using different approaches and equipment.

Step 4: Direct students to the ***Notebook*** activities. Students will need to conduct an internet search for Thermohaline Circulation (global conveyor belt) and the Gulf Stream.

Suggested questions:

- What do changes in the ice core composition polar ice caps tell us?
- What do the oceans tell us about climate change?
- How do snow, ice and large bodies of water influence climate?
- If you were a penguin in Antarctica what would you be worried about?

Follow-up:

The ***Find out more*** section allows students to explore Mawson Station, Antarctica in the present and in the past. You might like to set this section for homework. Students are asked:

1. How is life different at Mawson Station?
2. What sort of research activities occur there?
3. What job would you like to have?

4.8 Ocean acidification

Lesson outcomes

At the end of this activity students will be able to:

- explain how increased amounts of carbon dioxide absorbed in our oceans is leading to decreases in pH (acidification), and how this is likely to have a significant impact on marine ecosystems
- design and conduct an experiment which illustrates the potential impact of acidification of our oceans.

Key vocabulary:

Ocean acidification, carbon dioxide, pH, marine ecosystem

Equipment list

Each GROUP will require:

- ***Notebook***
- internet access
- Laboratory equipment outlined in the *Student Guide*.

Things to consider

- Ensure students understand acidity and the pH scale.
- Ensure the shells (or similar) used in the experiment are finely crushed and be prepared to monitor changes over a number of lessons to see the full effects.
- Encourage students to vary their method/approach as they see fit, and later evaluate its strengths and weaknesses as part of a formal experimental report.

Teacher content information

Ocean acidification describes the ongoing decrease in the pH of the Earth's oceans, caused by the uptake of anthropogenic carbon dioxide (CO2) from the atmosphere.

Slight changes in the pH of sea water have significant effects on marine life and habitats. Case study - Great Barrier Reef (refer to:- http://www.gbrmpa.gov.au/managing-the-reef/threats-to-the-reef/climate-change/how-climate-change-can-affect-the-reef/ocean-acidification)

The internet provides a variety of reliable information and resources on ocean acidification investigations for students of all ages (e.g. http://hilo.hawaii.edu/affiliates/prism/documents/Oceanwaterchemistryandoceanacidification.pdf)

OCEAN ACIDIFICATION

Carbon dioxide gas in the atmosphere reacts with the water in the oceans to form carbonic acid.

Carbon dioxide	+	water	→	carbonic acid
CO_2	+	H_2O	→	H_2CO_3

In the ocean, carbonic acid dissolves to form two ions.

Carbonic acid	→	hydrogen ion	+	bicarbonate ion
H_2CO_3	→	H^+	+	HCO_3^-

The H^+ ions increase the ocean's acidity. Scientists predict that the acidity will increase as increasing amounts of carbon dioxide are absorbed over time.

How will this impact our sea creatures? The shells of oysters, clams, sea urchins, lobsters, crabs, corals and the planktonic pteropods or 'sea butterflies' are made from calcium carbonate ($CaCO_3$). These creatures obtain calcium (Ca^{2+}) and carbonate (CO_3^{2-}) ions from seawater to form their shells.

Ca^{2+} + CO_3^{2-} → $CaCO_3$

Normal seawater has a pH of 8.2 and is naturally saturated with carbonate (CO_3^{2-}) ions. However, as the ocean becomes more acidic (more H^+ ions) the carbonate (CO_3^{2-}) ions become bicarbonate (HCO_3^-) ions.

H^+ + CO_3^{2-} → HCO_3^-

How will these marine creatures obtain the necessary carbonate (CO_3^{2-}) ions they need to make their shells?

How will these marine creatures keep their existing shells if the oceans become more acidic?

We know that calcium carbonate decomposes when added to an acid. It forms a salt, water and carbon dioxide.

Calcium carbonate + hydrochloric acid → calcium chloride + water + carbon dioxide

$CaCO_3$ + 2HCl → $CaCl_2$ + H_2O + CO_2

Will these creatures live if their shells decompose?

Ocean acidification has been called the 'osteoporosis of the sea'.

Lesson plan

Step 1: Discuss with students the use of indicators, such as bromothymol blue, to test for acidity.

Step 2: Remind students of pH measurement and the risks associated with handling chemicals.

Step 3: Discuss:

- the nature of experiments,
- determining hypotheses based on knowledge already acquired,
- the importance of the independent and dependent variables,
- how to control other influencing factors.

Step 4: Direct students to the three questions posed in the **Student Guide**. Encourage students to plan their own experiments in their ***Notebooks***, inclusive of risk assessment and then record their observations over a number of lessons.

Step 5: Students should be encouraged to formally document these experiments using a formal scientific report.

Suggested question/s:

- What do your experiments tell you about ocean acidification on a large scale?
- What are the limitations of your experiments and how would you improve it?
- What changes and adaptation could we see in marine ecosystems if there continues to be a significant increase in the absorption of carbon dioxide in our oceans?

4.9 Climate and biodiversity

Lesson outcomes

At the end of this activity students will be able to:

- describe the effects of global warming on the atmosphere, hydrosphere, and lithosphere and the likely impacts on species and the implications for biodiversity
- describe research by Australian scientists into the impacts of climate change on biodiversity

What ideas might your students already have?

Students will have extensive knowledge about ecosystems, adaptations etc., from previous units e.g., **Ecosystems and Change**, however their engagements with a systems approach may vary. It is also unlikely they will have drawn direct relationships between human activity, atmosphere, climate change and biodiversity on a global scale.

Key vocabulary:

Biosphere, biodiversity, ecosystem, species.

Equipment list

Each STUDENT will require:

- ***Notebook***
- internet access

Things to consider

- Video and internet resources, field excursions and direct contact with local scientists will enhance students' understanding and engagement with issues of biodiversity and climate change.
- Allow students to delve deep into a species of their own choosing and the research of a scientist through personal/direct contact, as this will generate greater empathy and understanding of the plight of animals affected by climate change.
- Depending on student experience and ability, this activity could be done as a homework or assessment task.

Teacher content information

The Australian Science Teachers Association (ASTA) resource book Australian Biodiversity (http://asta.edu.au/programs/natscienceweek/resources/resources2010) is well-worth adding to your resource library. It covers:

1. Biodiversity Basics – the ways in which biodiversity can be described, measured and recorded. This includes some notes on classification protocols
2. Australian Biodiversity – including the origins of our unique biodiversity
3. Threats to Australian Biodiversity
4. Conservation of Australian Biodiversity – at ecosystem, species and gene level.

Another useful resource is The Australian Government's Biodiversity site at http://www.environment.gov.au/biodiversity

Another useful reference is David Lindenmayer's book 'On borrowed time' (Penguin, 2007). In it he lists the potential impacts on biodiversity from rapid climate change. Some of them are:

- Contractions or expansions in the ranges of native species
- Altered breeding times (e.g. flowering patterns, bird migration, frog spawning)
- Altered breeding outcomes (e.g. sex of reptile offspring)
- Extensive coral bleaching
- Changed palatability of plant-based food for herbivorous animals
- Altered food webs and interactions between species
- Altered fire regimes

Lesson plan

Step 1: Work through the **Student Digital**, encouraging students to extend their learning by further research on the internet and by direct contact with scientists by email.

Step 2: If time is limited, use an **envoy** approach to summarising the videos and generate small group discussions about biodiversity and climate change. (For details about **envoy** refer to the *Science by Doing* professional learning resource Inquiry-based teaching.)

Suggested questions:

- Why worry about biodiversity?
- Climate change is relatively slow … will the impact on biodiversity be more dramatic?
- Will animals simply adapt to climate conditions, negating a biodiversity crisis?

Follow up:

Encourage students to engage with local scientists.

4.10 Communicating climate change

Lesson outcomes

At the end of this activity students will be able to:

- communicate the important aspects of climate change to a target audience.

What ideas might your students already have?

By now students will have a developing knowledge about climate change and its effects on Earth's systems and ecosystems.

Equipment list

Each GROUP will require:

- Internet access and computer devices
- Poster paper and markers
- Paper for cartoons
- Props for a play

Things to consider

- Provide sufficient lesson time for students to develop their presentations.
- Consider setting this activity as **summative assessment** for **Part 4**.
- Plan ahead and arrange a target audience within your school (other classes) or invite parents and community members to your class symposium.

Lesson plan

Step 1: Form the class into student groups and allow students the time to research each of the aspects for their presentation:

1. Causes
2. Possible climate changes
3. Impacts of climate change
4. Mitigation and adaptation to climate change

Step 2: Ask each group to choose the format (poster, PowerPoint, blog, cartoon/graphic novel, play) for their presentation and organise group members with specific tasks to progress towards completion. Students should scaffold their presentations to suit their target audience.

Step 3: Set a future lesson as a symposium where each group will present.

4.11 Sample test

A sample **summative test** and a **marking scheme** have been developed and are available to teachers from *Science by Doing* at sbd@science.org.au. Both are editable versions, so you can adapt them to your students' needs.

Note - *Science by Doing* provides sample assessment items and whilst every effort has been made, the security of these items cannot be guaranteed. *Science by Doing* encourages teachers to modify the items to suit individual teaching programs.

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